J. Basic Sci. Appl. Res., **4(1)1-15, 2018**

ISSN 2356-8879
Journal of Basic Sciences and Applied Research
www.textroad.com

Fito meteorologiya City: The Influence of the Amount of Relative Humidity of Air Ontogenesis Leaves of Birch

P.M. Mazurkin[1], A.I. Kudryashova[2]

[1]Dr. Sc., Prof., Volga State University of Technology, Yoshkar-Ola, Russia
[2]S. lec., Volga State University of Technology, Yoshkar-Ola, Russia

ABSTRACT

The development of birch leaves is very sensitive to changes in the amount of relative humidity. The aim is to compare the sum of three-hour values of relative humidity with the dynamics of growth and development of birch leaves in the growing season. The synergetic effect of the mutual influence of temperature and relative humidity is that the vegetation is influenced by two forces: 1) exponential growth with increasing meteorological parameter; 2) decrease in the exponential growth law. The daily cycle of relative humidity is more important for the leaves than the temperature. The amplitude of the first oscillation varies within the relative humidity of 10%. The hypothesis of the moon influence on the development and growth of birch leaves is put forward. The length and width of the leaves with increasing temperature increase the amplitude, and with increasing relative humidity, on the contrary, reduce it. The scatter of residues is different. In the first half-wave to a minimum of 290 the amount of relative humidity dispersion increases and then decreases. At the stage of increasing the amount of relative humidity to the second maximum, the dispersion increases. Residues 50-th term is less than 0.5%. It can be argued that for each year at any weather station can be carried out during the growing season fractal wavelet analysis of the sum of the relative humidity of the surface layer of atmospheric air.

KEYWORDS: birch leaves, the vegetative period, the dynamics of amounts, temperatures settings 20 account leaves, the dynamics of behavior, wavelet analysis

1. INTRODUCTION

Changes in basic climatic parameters are usually studied for human habitation purposes [14]. Researchers pay more attention to the increase in summer air temperature [15, 29]. Biometeorological assessment of climate and air quality is performed for urban and landscape planning [35]. The microclimate in the urban environment is formed mainly by trees, in which the vegetation period will grow until the end of the century [33]. Our article shows the regularities of the influence of the amount of relative humidity on the leaves of birch in the growing season.

In [1], the existence of an asynchronous relationship between the temperature of the near-surface air layer in different zones of the Earth is shown. This temperature is affected by direct solar radiation [2], but it also depends on the terrain. The city of Yoshkar-Ola is located in the plain, so the influence of the relief can be neglected. It ranks tenth in the country among the clean cities of Russia.

According to [3], meteorological factors affect air pollution, and in summer air temperature strongly influences. Most of the studies in aerobiology in 1957-2017 were devoted to the cyclic distribution of birch pollen [28]. The forecast of temperature [9] according to the climatic model of Germany showed that the average temperature increase will be 1 0C until 2100 in summer. At the same time, from January to may there is a strong temperature fluctuation due to cyclonic influences [10]. The dynamics shows a more uniform distribution of air temperature in summer [21].

Metric parameters of leaves [20] depend on the vegetation period. With the growth of the growing season, the amount of active temperatures varies little [21]. In Berlin [22] for 252 the tree of lime in the cores by the distance from the center to the periphery was revealed changes of the increment of the thickness of the trees for 50 to 100 years. This shows that the development of trees is also due to humidity.

The forests of China have nonlinear oscillations of the leaf surface [24]. At the same time, winter cooling conditions can strongly influence Bud blooming [33]. The leaves unfold as a reaction to the warming of the air. For many species of trees the temperature range 0-5 0C is effective. Global warming leads to higher tree growth rates [23]. However, we have not found any publications on the dynamics of relative humidity.

Relative humidity compared to temperature has a larger interval between the pre-dawn and midday values [22]. Therefore, we have abandoned the average daily meteorological data and have taken the initial values every three hours. Quantization was performed with respect to the vegetation period of birch leaves hanging. According to [24] birch and its leaves are promising in bioindication of the urban environment, while woody plants reduce temperature and increase humidity. Seen [30] that urban environment, particularly asphalt pavements, shifting of phenological phase leaves of the trees. In the Beijing Botanical garden [31] the phases were compared with the rhythm of temperature and it turned out that the spring phase changes more. In the USA, remote sensing revealed a relationship between the quality of snowmelt and the onset of phenological phases [44]. The article [42] shows the synergetic effect of temperature and humidity on forest diseases: the peak of diseases increases with increasing humidity and decreasing air temperature.

* **Corresponding Author:** P.M. Mazurkin, Dr. Sc., Prof. Volga State University of Technology, Yoshkar-Ola, Russia.
Email: kaf_po@mail.ru

Phenology allows us to measure the impact of climate change on ecosystems [32]. For 14 plant species in Lithuania, the vegetation period begins on April 27 (3 days) [34]. In different leaves the vegetation period lasts 175-180 days, while high humidity reduces the flow of soil moisture [43]. There is a nonlinear relationship from the time of Bud break between seven species of conifers in Kazakhstan. At the same time, age has a significant impact [45]. For 12 European countries (3000 km Meridian) for 1970-2010 for long-term changes in phenological phases had maximum and minimum temperatures, rather than average. At the same time, there is an increase in spring temperatures at the end of the XX century [49].

Birch hanging in Estonia proved to be effective against the drought of 2010. At the same time, trees adapt well to the increase in air humidity, and the importance of relative humidity is even higher compared to air temperature [46]. Increasing air humidity reduces temperature and biomass accumulation in young birches, especially susceptible leaves [47]. Temperature has a greater influence than precipitation [48]. The leaves of young oaks have better chemical protection compared to Mature ones [50].

Until now, no dependencies have been found on the effect of humidity and temperature on the appearance of leaves. It is believed that, in addition to solar radiation, it is affected by spring warming and winter cooling. Therefore, the influence of humidity on the development and growth of birch leaves and other tree species should be further investigated [51].

2. MATERIALS AND METHODS

The main object of global and local environmental monitoring can be a birch with leaves without cutting them [4-8; 11-13; 16-19}. Vysokolikvidnye model with wave components were obtained on account of the leaves of the young birch trees grown in environmentally friendly conditions. It is proved that air pollution suppresses the mechanism of oscillatory adaptation of leaves in the process of annual (seasonal) ontogenesis.

The regularities showing relatively weak influence of groups of five leaves located on separate branches, depending on the azimuth, radius from the axis of the trunk and the angle of adjunction of the branch to the trunk of a young birch [12, p.118-166] are also obtained. Each record sheet was marked with a white thread with a tag with the number of the sheet tied to the petiole at the base of the sheet.

The method of measuring the length, width, perimeter and area of leaves includes such actions [16-19]. On a sheet put a transparent pallet with a grid (cages 2×2 mm) so that the average line along a pallet coincided with an axis of a longitudinal vein of a leaf. Then the sheet with a pallet is photographed with a digital camera with the function of storing photographs. On the computer, the photo sheet is cut, then increased to count the cells to A4 format.

In contrast to [12] in this article the last point on the fact of falling of the sheet is excluded, since the death of the sheet is observed at non-zero parameters. Added a new parameter - the amount of relative humidity every three hours (table. 1) at the meteorological station (2 km from the young birch).

Table 1: Relative humidity since the beginning of the growing season of birch leaves hanging

Date	Term, clock	Time t ,day	Relative humidity воздуха W , %	The sum of the Relative humidities $\sum W$, %	Amount for calculation $\sum_W = \sum W / 100$
02.05.2014	1	0.042	83	83	0.8
	4	0.167	90	173	1.7
	7	0.292	89	262	2.6
	10	0.417	51	313	3.1
	13	0.542	42	355	3.6
	16	0.667	44	399	4.0
	19	0.792	44	443	4.4
	22	0.917	65	508	5.1
03.05.2014	1	1.042	92	600	6.0
	4	1.167	96	696	7.0
	7	1.292	94	790	7.9
	10	1.417	74	864	8.6
	13	1.542	68	932	9.3
	16	1.667	51	983	9.8
	19	1.792	51	1034	10.3
	22	1.917	87	1121	11.2
…	…	…	…	…	…
01.10.2014	1	152.042	93	82118	821.2
	4	152.167	92	82210	822.1
	7	152.292	89	82299	823.0
	10	152.417	89	82388	823.9
	13	152.542	89	82477	824.8
	16	152.667	77	82554	825.5
	19	152.792	85	82639	826.4
	22	152.917	84	82723	827.2

Here, the current time is counted every three hours. Relative humidity in the surface layer of the atmosphere is taken from the meteorological station. Then the relative humidity cumulate is calculated. During the growing season, the amount of relative humidity is formed in 82723%. To obtain acceptable values for the calculation is taken by the formula $\sum_W = \sum W / 100$ division by 100.

Table 2 shows a fragment of experimental data with birch leaves.

Table 2: A comparison of the amount of relative humidity with parameters 20 account the leaves of the silver birch

№ p / n	Date	Time t, day	No. sheet's	Amount $\sum_T$	a, mm	b, mm	P, cm	S, cm^2
1	02.05.2014	0	1	0.8	0	0	0	0
2	21.05.2014	19	1	83.4	26.0	20.2	7.35	3.32
3	29.05.2014	27	1	117.7	34.4	26.6	12.73	7.66
4	05.06.2014	34	1	142.0	42.0	33.8	13.58	9.04
5	19.06.2014	48	1	221.0	49.6	41.8	14.99	14.90
6	03.07.2014	62	1	296.5	54.4	46.2	19.23	17.84
7	24.07.2014	83	1	402.3	62.2	50.4	19.80	20.36
8	21.08.2014	111	1	563.4	69.0	57.2	32.24	24.44
9	04.09.2014	125	1	652.2	62.2	50.4	29.98	21.64
10	17.09.2014	138	1	736.0	54,4	46,2	19,23	17,84
11	24.09.2014	145	1	776.8	49,6	41,8	14,99	14,90
12	02.05.2014	0	2	0.8	0	0	0	0
13	21.05.2014	19	2	83.4	26.4	20.4	8.20	3.50
14	29.05.2014	27	2	117.7	34.8	27.0	12.73	7.66
15	05.06.2014	34	2	142.0	42.4	34.2	13.58	9.04
16	19.06.2014	48	2	221.0	50.0	42.2	17.25	14.90
…	…	…	…	…	…	…	…	…
216	24.07.2014	83	20	402.3	68.8	57	27.44	27.70
217	21.08.2014	111	20	563.4	76.4	65	32.81	28.52
218	04.09.2014	125	20	652.2	68.8	57	30.83	24.34
219	17.09.2014	138	20	736.0	62.0	50,4	20,36	19,80
220	24.09.2014	145	20	776.8	54.0	45,8	17,25	17,94

It adopts the following conventions:

t - current time from the moment of birch buds blooming (may 2, 2014) to the last measurement in the growing season, day (September 24, 2014);

$\sum_T$ - the sum of temperatures from the moment of bud blooming of birch hung every three hours of measurements at the meteorological station, 0.01^{0}C;

a - leaf length along the main vein, measured from the junction of the petiole with the leaf plate of the plant to the end of the leaf apex, mm;

b - the width of the sheet at the extreme points across the sheet plate or the total width of the sheet in the largest cross-section of the sheet, mm;

P - the perimeter of the sheet, cm;

S - the area of the sheet, measured by the number of cells 2×2 mm in size and the number of cells located along the perimeter of the sheet, cm^2.

The physical and mathematical approach assumes understanding of a dynamic series on the vegetation period as reflection of some compound process of vital activity of accounting leaves. The behavior of each sheet occurs as an oscillatory adaptation to changes in the environment of this sheet. And adaptation happens for many decreasing quanta of interaction.

Under this assumption, any equation of the wave component in the vibrational adaptation quantum can be written as a wavelet signal [36-41]

$$y_i = A_i \cos(\pi x / p_i - a_{8i}) \, , \; A_i = a_{1i} x^{a_{2i}} \exp(-a_{3i} x^{a_{4i}}) \, , \; p_i = a_{5i} + a_{6i} x^{a_{7i}} \, , \qquad (1)$$

where A_i – amplitude (half) of asymmetric wavelet (axis y); p_i – half-period of oscillation (axis x); $a_{1i} ... a_{8i}$ - model parameters (1) obtained in pairs from statistical data in the software environment CurveExpert-1.40 (http://www.curveexpert.net/) according to tables 1 and 2; i - the number of the member (1).

According to the formula (1) with two ***fundamental physical constants*** e (the Neper number, or the number of time) and π (the Archimedes number, or the number of space), a ***quantized wavelet signal*** is formed from within the phenomenon and/or process under study. And these quanta are arranged one behind the other according to the law of the fractal Mandelbrot. The concept of asymmetric wavelet in the unknown signal (1) allows us to abstract from the physical meaning of the series of distributions by the values of the studied and measured factors.

3. The mutual influence of relative humidity and air temperature

The vegetation period of birch leaves continued from 02.05.2014 to 30.09.2014. During this period, 1224 temperature and relative humidity values were measured at the meteorological station after 3 hours.

Direct influence of temperature on relative humidity (Fig. 1) gave a two-term trend in the form of a pattern with a correlation coefficient of 0.6436

$$W = 71.90185\exp(0.060669T^{0.94781}) - 0.66723T^{1.79274} . \qquad (2)$$

A similar design of the model was obtained for feedback (Fig. 1) with correlation coefficient 0.6229 < 0.6436 as an equation

$$T = 8.96574\exp(0.63420W^{0.326271}) - 0.93323W^{1.09464} . \qquad (3)$$

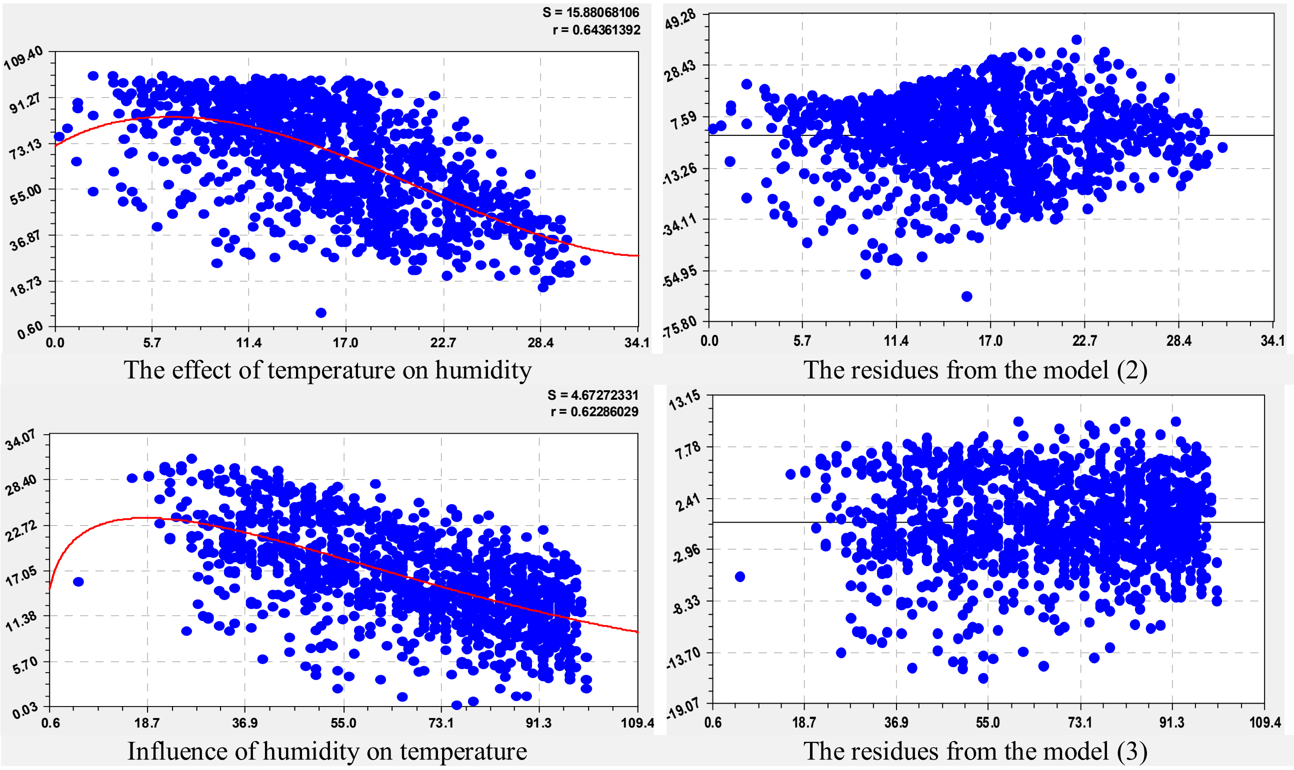


Figure 1. Graphs of trends in the mutual influence of temperature and relative humidity in the growing season of birch leaves

By correlation coefficients, the direct effect is more significant than the reverse. According to the formula (2) under the condition $T = 0$ ^{0}C we obtain a relative humidity of 71.9%. Provided $W = 0$ % of the equation (3) we obtain a temperature of 8.97 ^{0}C.

Next, take into account the period of winter cooling of birch leaves hanging and take a series (2185 points) temperature and relative humidity from January 1. Because of the winter negative temperatures, we will adopt a new scale $K = T + 273.15$ with positive temperature values in degrees Kelvin.

Direct influence of absolute temperature on relative humidity (Fig. 2) gave the same trend design with a correlation coefficient of 0.4862

$$W = 0.59298\exp(0.025515K^{0.98465}) - 7.76891 \cdot 10^{-19} K^{8.43533} . \qquad (4)$$

A similar design of the model was obtained for feedback (Fig. 2) with correlation coefficient 0.4644 < 0.4862 as an equation

$$K = 277.76227\exp(0.0025571W^{1.30766}) - 0.085558W^{1.88838} . \qquad (5)$$

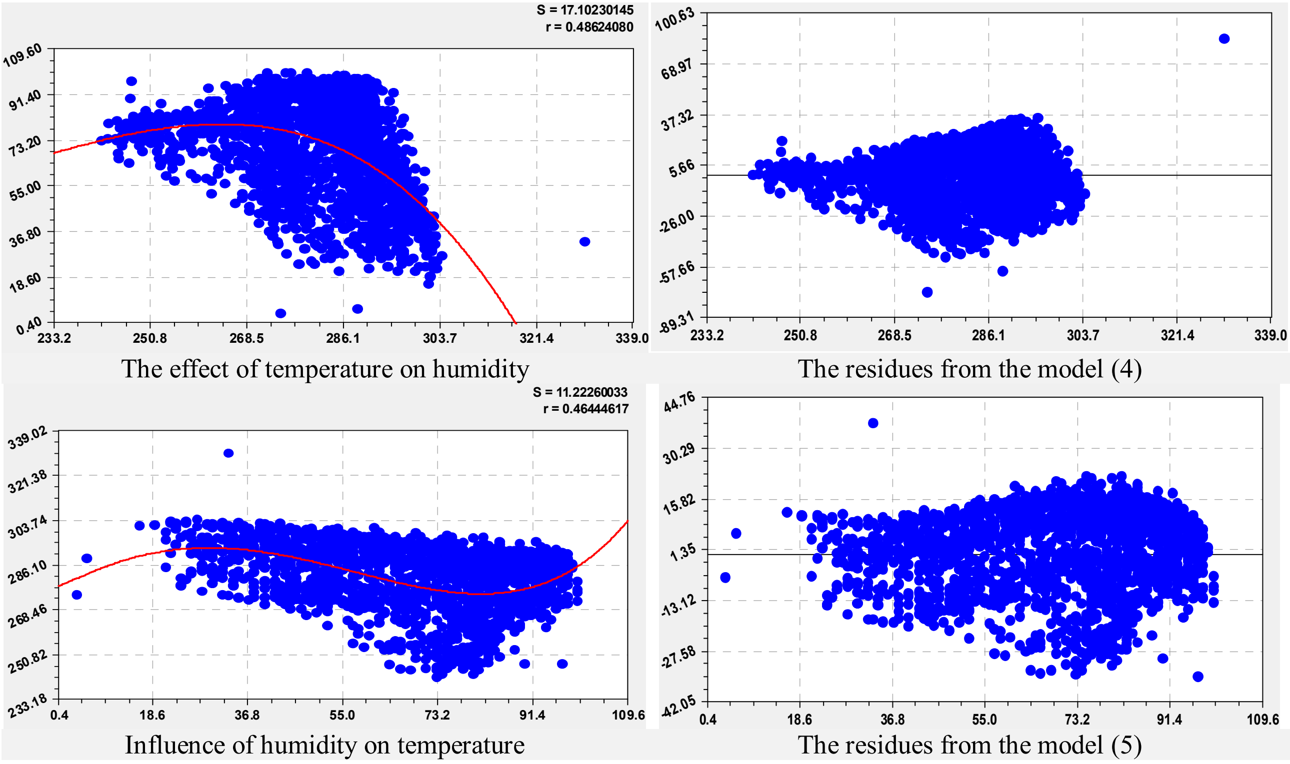


Figure 2. Trend graphs of the mutual influence of temperature and relative humidity in winter cooling and vegetation period of birch leaves

By correlation coefficients, the direct effect is also more significant than the reverse. According to the formula (4) under the condition $K = 0$ °K we obtain a relative humidity of 0.59%. Provided $W = 0$ % of the equation (5) we obtain a temperature of 277.76 – 273.15 = 4.61 < 8.97 °C. All equations have the same construction. The first member of the trend is the law of exponential growth [36-41], and the second – the law of exponential crisis (because of the negative sign) growth.

Thus, the synergetic effect of the mutual influence of temperature and relative humidity is that the vegetation processes in plants are influenced by two forces: first, exponential growth with increasing influencing meteorological parameter; second, the decrease in the values of meteorological parameters according to the exponential growth law.

4. Dynamics of relative humidity during the growing season birch leaves

According to the model (1), 17 components were identified, of which the first two members are a trend (table 3). Then asymmetric wavelets are obtained with correlation coefficients less than 0.1. The first 6 members are given in figure 3.

Table 3: Parameters of wavelets dynamics of relative humidity during the growing season of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}}\exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i}+a_{6i}x^{a_{7i}})-a_{8i})$								Corel. coefficient. r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
1	51.62783	0	0.0043162	1	0	0	0	0	0.8170
2	6.48180	4.24211	6.61633	0.21451	0	0	0	0	
3	27.42225	0	0.20269	0.51228	8.54706	-0.30871	0.32986	-1.33452	
4	-18.75125	0	0.020307	1	10.53494	0	0	3.11684	
5	8.80538	0	0	0	19.15750	0.00060425	2.01107	1.11697	
6	-18.45401	0	0.00071943	1	0.50014	0	0	4.16166	
7	-2.14634	0	0.00010140	1	2.10594	0	0	-1.12151	0.1260
8	-2.29781	0	-0.0028615	1	3.26231	0.00042438	1.22827	1.37389	0.1730
9	7.37841	0	0.037299	1	0.72075	0	0	-0.82107	0.1318
10	-13.47541	0	0.068016	1	1.42833	0	0	0.68503	0.1836
11	-2.82878	0	1.75315e-5	2.22844	2.81592	0.059271	0.20078	2.06118	0.1323
12	0.97500	0	-0.00015392	1.82498	1.91831	0	0	3.14020	0.1283
13	2.43088	0	0.0019103	1	3.53337	0.00046662	1.26610	4.89817	0.1336
14	-2.27957	0	0.0014638	1.09853	5.13755	7.18424e-5	1.36748	-0.13804	0.1236
15	-2454.2449	0	6.60776	0.026463	10.31467	-2.60648	0.089426	-2.88319	0.1079
16	-1.28946e-6	0	-11.48528	0.052513	7.60999	0	0	-3.38880	0.1657
17	-0.016820	0	-2.82197	0.14214	13.11529	0.00016785	1.77220	-0.11859	0.2163

The first term of the model (1) is the law of exponential death in a simplified form. This is Laplace's law in mathematics, Mandelbrot in physics, pearl in biology and Pareto in econometrics. With a constant half of the amplitude in such a design among the 17 members is 7 pieces. For example, the sixth member has a constant half-amplitude oscillations in 0.50014 day. The second component is a biotechnical law [36-41], which determines the nature of the development and growth of birch leaves in the growing season.

The graphs of the first six members from table 3 are shown in figure 3.

The increase in relative humidity (positive sign before the wavelet) is influenced by the components 1-3, 5, 9, 12 and 13. The remaining members have a negative sign in front of the formula and therefore characterize the decrease in humidity. The sixth component and a half of the constant amplitude 0.50014 days received the greatest adequacy of 0.7192 (from the total correlation coefficient 0.8170). The same wavelet for the dynamics of the temperature of the received correlation coefficient 0.6880.

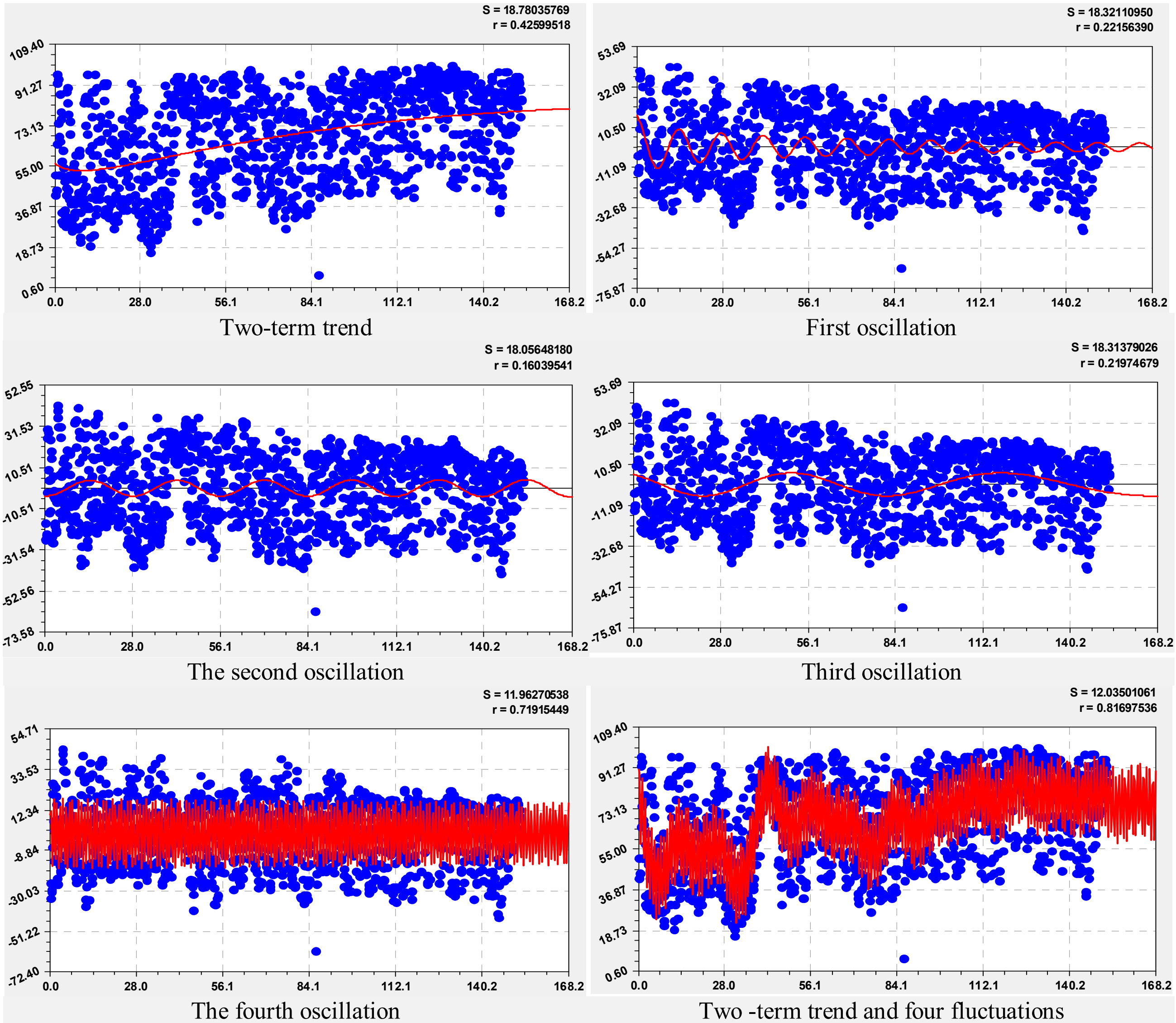


Figure. 3. Trend charts and four fluctuations with parameters from table 3

Then it turns out that the daily cycle of relative humidity is more important for the development and growth of birch leaves in comparison with temperature. We haven't found regularities of the joint effect of temperature and humidity: as long as each of them is affected by itself.

5. Dynamics of the sum of relative air humidity during the growing season birch leaves

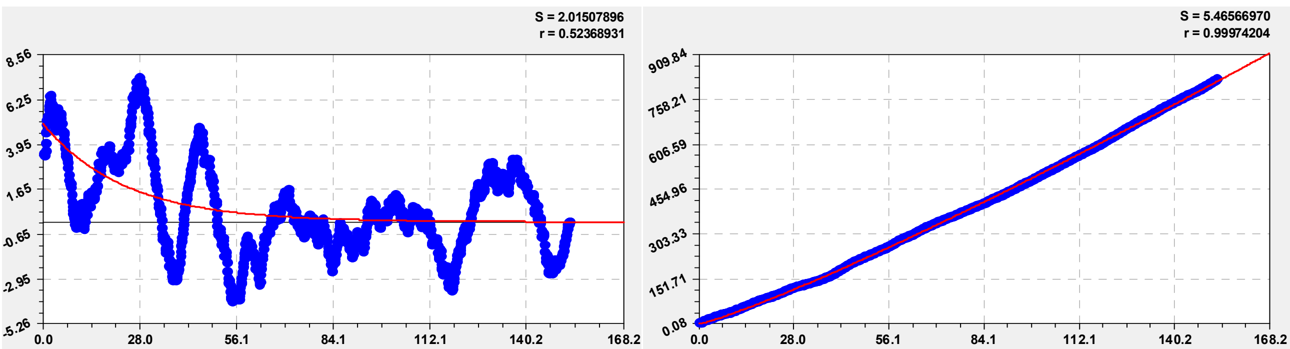
According to table 1, 50 members of the model (1) were obtained for the dynamics of the sum of relative air humidity, the parameters of which are given in table 4.

Table 4: Parameters of wavelet dynamics of the sum of relative air humidity during the growing season of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}} \exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i} + a_{6i}x^{a_{7i}}) - a_{8i})$							Corel. coefficient r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
1	5.98756	0	0.015218	1.39390	0	0	0	0	1.0000
2	2.67874	1.13674	0	0	0	0	0	0	
3	4.66921	0	-0.00019035	1.70234	20.59193	0.00044775	2.02267	2.45707	
4	-2.41676	0	0.039484	0.40481	9.60540	0.013704	1.11025	4.61502	
5	-0.12269	1.44032	0.12628	0.80414	5.29369	0.054479	0.87544	5.34115	0.8136
6	0.12068	0	-0.0066559	1.15668	6.04754	0.0038546	0.99278	3.92031	0.5283
7	-0.26494	0	0.0012423	1	-0.38801	2.66046	0.35646	6.00746	0.3001
8	3.01802e-8	0	-13.53416	0.037426	3.08838	0.033191	0.47570	2.91386	0.3336
9	-0.20022	0	0.0011558	1	5.95328	-0.0034358	1	-2.75458	0.2568
10	-0.50603	0	0.0088997	1	3.46013	0.19717	0.26729	-0.13893	0.4268
11	-7.16536e-10	0	-16.40838	0.039629	9.61006	0	0	1.79997	0.3596
12	0.23511	0	0.0064481	1	2.77516	0.0016443	1.00027	1.85195	0.2640
13	-0.98295	0	0.24586	1	1.95674	0	0	0.44593	0.2138
14	0.17614	0	0.0020210	1	9.03977	-2.72924	0.084901	-1.56686	0.2752
15	0.19514	0	0.0019866	1	7.95776	0	0	-1.54103	0.3173
16	0.038973	0	-0.0092521	0.78472	14.61186	-0.0075175	1.02138	0.43901	0.1068
17	-0.24275	0	1.68137e-5	1.82356	0.50001	0	0	-0.93506	0.4595
18	0.12061	0	-0.0034941	1	2.58979	-0.0061989	0.80921	-4.11782	0.3632
19	-0.00032156	0	-3.62607	0.10435	2.58331	0	0	0.71166	0.2395
20	-0.074843	0	0.0013379	1	6.15910	0	0	0.40388	0.1689
21	-0.00011995	0	-4.36820	0.091103	2.42849	0	0	-4.55123	0.2040
22	0.075332	0	-0.0014148	1	3.28895	-0.0015583	1.01710	-3.97153	0.2166
23	-0.21439	0	0.020226	1.00002	1.48777	4.87784e-6	1	1.22635	0.2282
24	-0.084065	0	-0.00046135	1	2.24270	-0.00092094	1.06711	-1.61124	0.2362
25	.041680	0	0.00025857	1	7.24277	0	0	0.77438	0.1140
26	0.015469	0.82513	0.10744	0.68550	1.64327	-0.0041484	0.58849	-4.51131	0.1790
27	-2.18659e-6	3.77330	0.071838	0.98715	2.02865	-0.00092996	1.14667	5.46132	0.3154
28	-0.00015453	2.66057	0.034599	1.16533	3.01282	0.0012316	1.45777	-0.16952	0.3321
29	-2.73989e-13	7.66368	0.033107	1.19318	3.07615	0.018423	0.69742	0.64075	0.3956
30	-1.06631e-6	2.30656	0	0	1.77321	0.00010215	0.99940	-2.22954	0.1716
31	-22470.009	0.72875	11.42807	0.082182	2.77417	0.18252	0.62403	2.20512	0.2363
32	0.24659e-5	2.71990	0.11603	0.83905	8.08735	-0.0078014	0.95317	-2.72222	0.0992
33	-0.00085961	1.77855	0.032558	1.00262	2.72622	4.57478e-5	1.10236	2.73006	0.4375
34	3.51149e-8	4.04028	0.033039	1.06708	2.89087	0.00026439	1.20989	-1.41780	0.1362
35	0.0038863	0.89721	0.062252	0.78047	2.40713	0.0018813	0.85527	2.26885	0.1094
36	-1.80567-5	2.00210	0.011028	1.00020	2.20777	6.26809e-6	1	-0.054942	0.2064
37	8.50127e-7	2.25816	3.83876e-5	1	1.99838	-0.00022845	1	1.01606	0.1299
38	-0.00024797	1.35679	0.020233	0.98968	1.90241	-0.0016127	1.01178	-1.94667	0.2062
39	0.0032271	0.49266	0	0	1.66699	0.00010162	0.99743	4.16687	0.1174
40	4.74117e-7	2.99578	0.017487	1.07972	1.61264	0	0	1.52858	0.1194
41	0.074770	0.068844	0.0030968	1.04468	1.41668	-0.0043731	0.33224	-0.33219	0.3289
42	1.59615e-5	2.12507	0.017958	1.02917	1.18467	5.25497e-5	0.73981	1.68989	0.1301
43	7.57749e-9	5.60796	0.10623	1.02376	0.99575	-2.32884e-5	1.13266	0.90121	0.1745
44	6.18549e-31	18.97169	0.028020	1.45120	0.91243	0	0	-1.45393	0.1880
45	4.47234e-10	5.34298	0.067282	1	0.80332	2.48306e-8	1	-2.18042	0.0909
46	1.86146e-18	12.07097	0.10825	1.13414	0.60451	0	0	-1.65207	0.1482
47	-0.027182	0	-0.00044512	1.28577	5.40669	0.0013138	1.01225	-0.79157	0.1522
48	0.098089	0	0.77862	0.10477	51.88536	-0.39511	0.76271	0.57037	0.1582
49	0.013199	0	-0.0083200	1	1.09346	2.64473e-7	1	0.094649	0.1433
50	1.25656e-5	2.50087	0.037837	1.00251	21.00895	-0.0060825	1.22267	1.15612	0.1853

Compared with table 3, the sum of relative humidity was more informative. As a result, the quantum effect of humidity was much more significant than temperature. The first four terms gave a correlation coefficient of 0.9999887 ≈ 1.0000. Then the rest 46 of the oscillations give a raise of adequacy of the entire 1 – 0.9999887 = 0.0000113.

The classic trend in table 4 has two members (Fig. 4): the first is the law of exponential death, it was not in the dynamics of the sum of temperatures, and the second term, as for temperature, is the law of exponential growth.



The law of exponential death | Exponential law

Figure. 4. Charts of trend components with parameters from table 4

The exponential law has a correlation coefficient of 0.999742, so all the other 49 members of the General model (the wavelet quantum analysis can be continued further, but with an adequacy of less than 0.1) give only 1 – 0.999742 = 0.000258. It is these «weak» fluctuations (quanta of behavior) that determine the nature of the influence of relative humidity on the leaves of the birch.

The start of the first member of the trend begins with about 6% (it was more at the beginning of the movement of birch SAP until 02.05.2014). Then we can assume that the birch for 180 million years of evolution is well adapted to changes in air humidity. And it reacts less to the dynamics of air temperature.

Figure 5 shows graphs of the oscillations of the members of No. 3-8.

The amplitude of the 1st oscillation varies within the relative humidity of 10%. If there was no such interval of changes of humidity, there would be no quanta of influence on activity of a birch. The nature of the first oscillation can hypothesize the influence of the moon on the development and growth of leaves of silver birch. The half-period of oscillation at the beginning of the growing season is three weeks (according to table 20.59193), and weeks and months are measurements of lunar cycles. There are other fluctuations: for example, wavelet number 10 has a weekly cycle. The amplitude of oscillation No. 1 increases and the period increases. Because of this, in the month of October there is a complete fall of birch leaves hanging. The launch of the mechanism of subsidence of the sheets contain themselves.

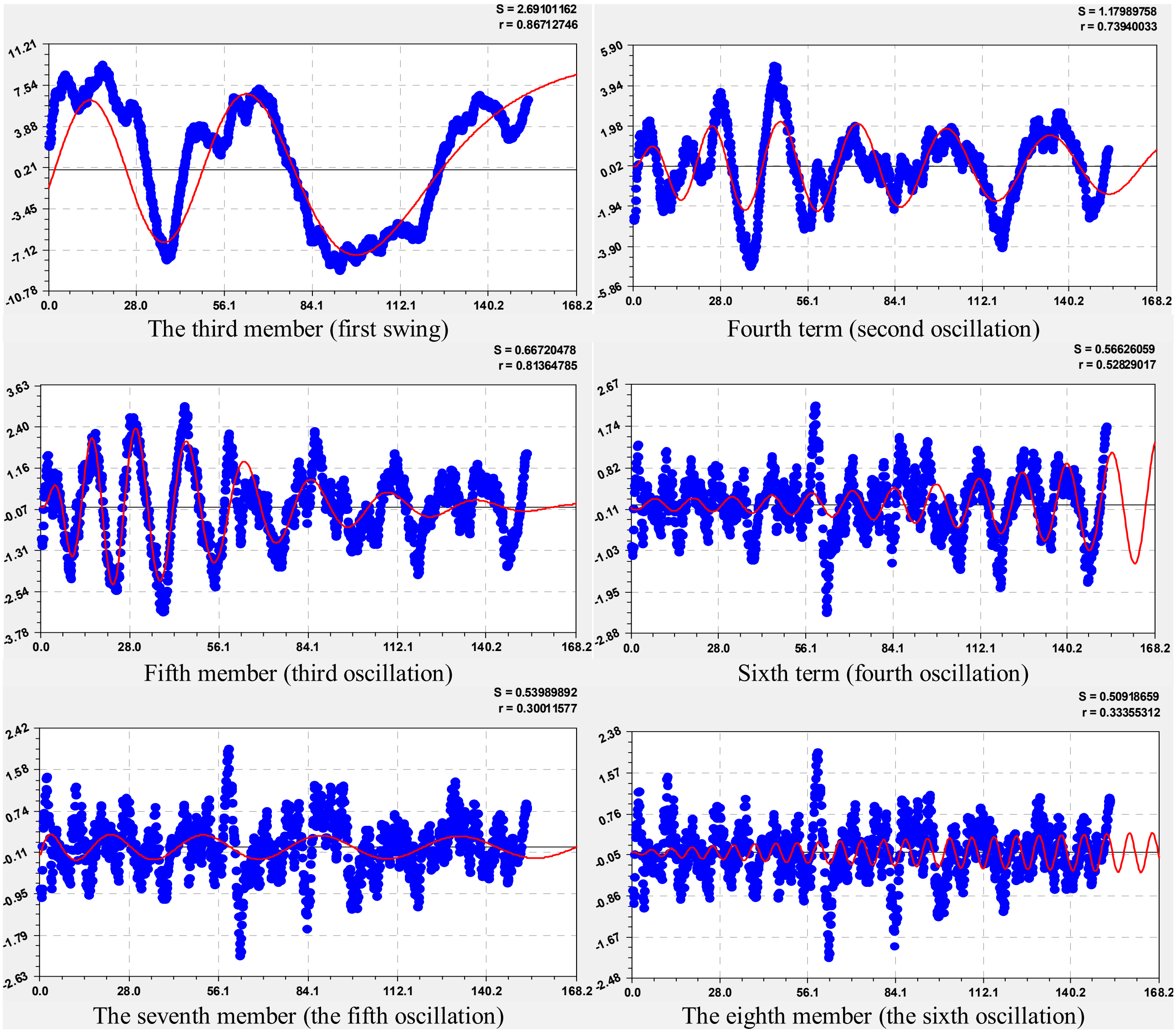
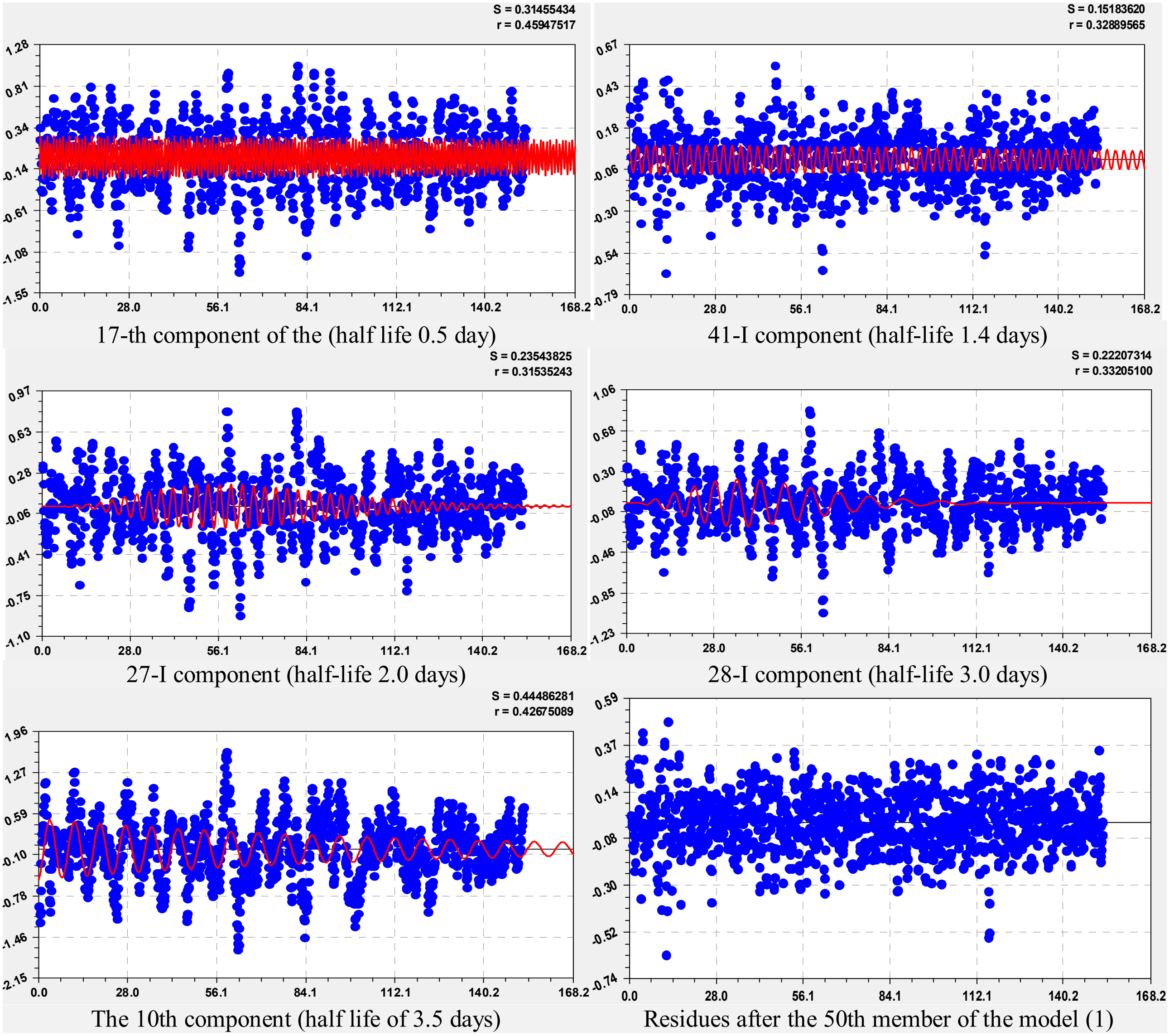


Figure 5. Charts 6 fluctuations after the trend in the sum of relative humidity

The hierarchy of impact quanta can be revealed by fractal analysis of variance S (in the upper right corner). In descending order of correlation coefficient in figures 4 and 5 wavelets is as follows: strong ties No. 2 – 0.9997; No. 3 – 0.8671; No. 5 – 0.8136 and No. 4 – 0.7394; average No. 6 – 0.5283 and No. 1 – 0.5237. Weak links in dynamics have fluctuations: No. 17 – 0.4595; No. 33 – 0.4375; No. 10 – 0.4268; No. 29 – 0.3956; No. 18 – 0.3632; No. 11 – 0.3596; No. 28 – 0.3321; No. 41 – 0.3289; No. 15 – 0.3173 and No. 27-0.3154. Some of them are given in figure 6.



17-th component of the (half life 0.5 day)

41-I component (half-life 1.4 days)

27-I component (half-life 2.0 days)

28-I component (half-life 3.0 days)

The 10th component (half life of 3.5 days)

Residues after the 50th member of the model (1)

Figure. 6. Graphs of oscillations of the sum of relative air humidity

Residues 50-th term is less than 0.5%. Then it can be argued that for each year at any weather station can be carried out during the growing season fractal wavelet analysis of the sum of the relative humidity of the surface layer of atmospheric air.

6. Effect of the sum of relative air humidity on the growth of birch leaves along the length

Next, consider the effect of the sum of relative humidity on the four indicators in 20 leaves. The model parameters are given in table 5.

Table 5: Influence of the sum of relative humidity on the parameters of birch leaves

Number i	Asymmetric wavelet $y_i = a_{1i}x^{a_{2i}}\exp(-a_{3i}x^{a_{4i}})\cos(\pi x/(a_{5i}+a_{6i}x^{a_{7i}})-a_{8i})$								Corel. coefficient r
	The amplitude (half) the fluctuations				Half-period of oscillation			shift	
	a_{1i}	a_{2i}	a_{3i}	a_{4i}	a_{5i}	a_{6i}	a_{7i}	a_{8i}	
Effect on the length of 20 leaves of birch									
1	0.63863	0.87334	0.00030051	1.26318	0	0	0	0	0.9938
2	-0.089944	0	-1.88126	0.12847	96.11899	0.82306	0.74748	-0.14481	
Effect on the width of 20 leaves of birch									
1	0.45554	0.89729	0.00034169	1.23868	0	0	0	0	0.9931
2	-0.0014401	0	-6.52575	0.033185	-14.26778	27.32311	0.29342	1.35723	
The effect on the perimeter of the 20 leaves of the silver birch									
1	0.062946	1.14633	0.0023785	0.98784	0	0	0	0	0.9773
2	-0.0048870	0	-3.70240	0.099178	250.25908	-0.00036961	1.63184	4.16804	
Effect on the area of 20 leaves of birch									
1	0.0033362	1.72372	0.0039449	0.98838	0	0	0	0	0.9871
2	1.91033e-5	0	-7.67776	0.069574	141.28833	0.0082407	1.34847	3.10264	

The perimeter and area give smaller values of the correlation coefficient.

Figure 7 graphs the change in the length of leaves from the amount of relative humidity levels.

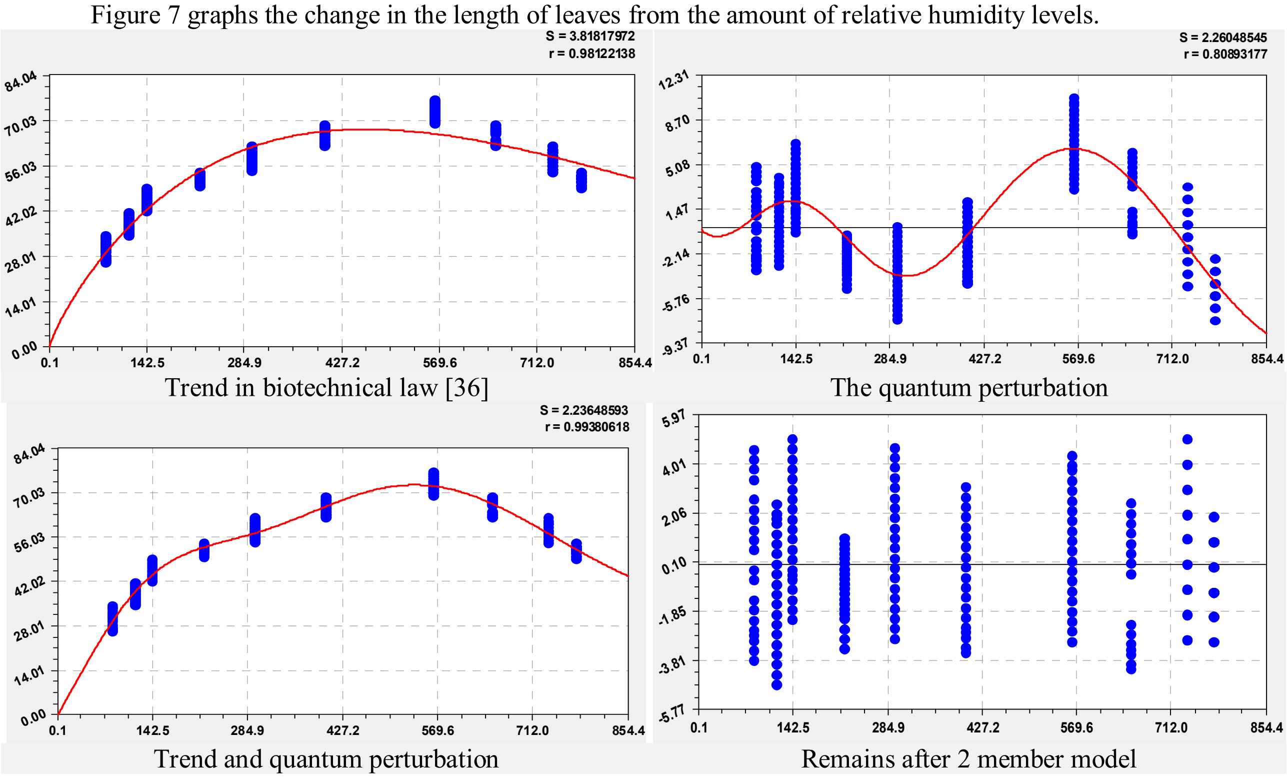


Figure 7. Influence of the amount of relative humidity during the growing season on the length of birch leaves

Comparison with the effect of temperature shows that the length and width of the sheet adequacy is almost the same (for the temperature, respectively 0.9939 and 0.9938). But the influence of relative humidity is characterized by a decreasing amplitude (increasing for temperature), while the oscillation occurs crisis with a negative sign in front of the component. Then it turns out that the length and width of birch leaves hanging with increasing temperature increase the amplitude, and with increasing relative humidity, on the contrary, reduce the amplitude of oscillatory adaptation.

7. Effect of the sum of relative air humidity on the growth of birch leaves in width

The effect on the width of 20 leaves of birch is shown in figure 8.

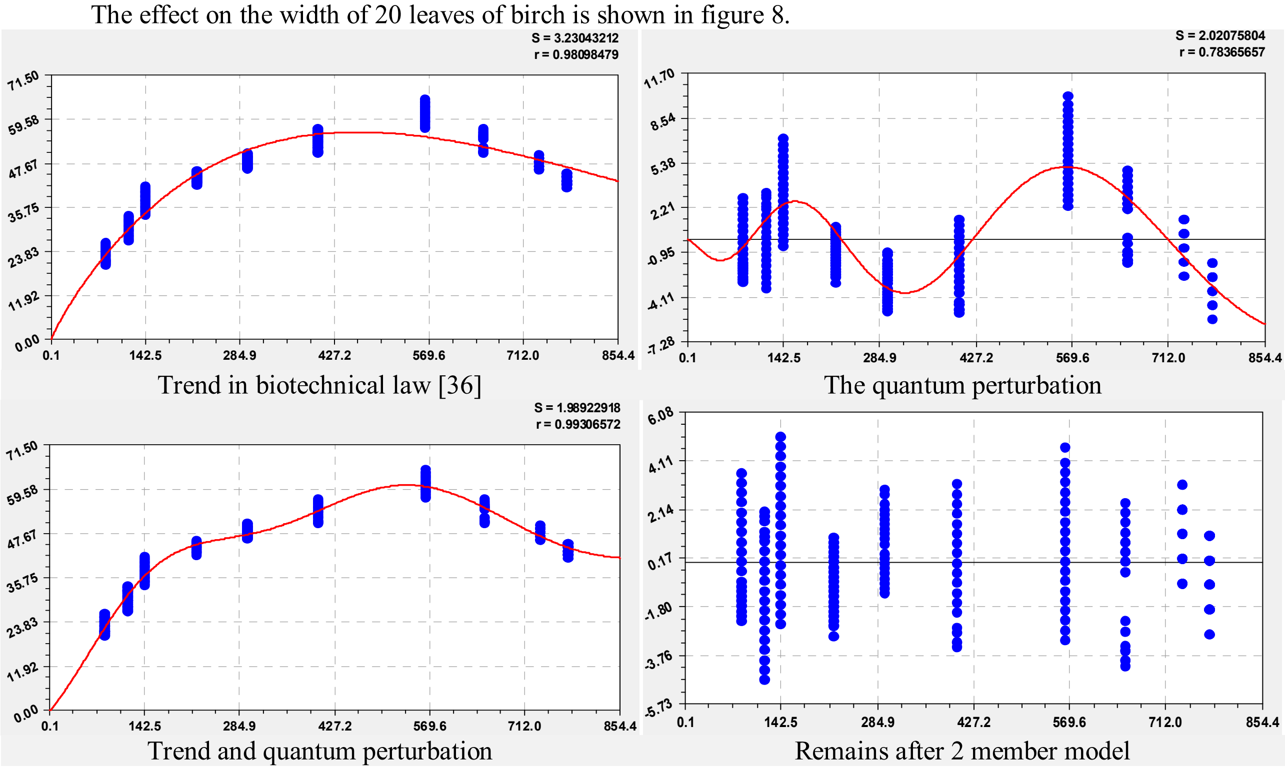


Figure 8. Influence of the amount of relative humidity during the growing season on the width of birch leaves

The spread in the residuals after the two-term model with the parameters from table 5 shows the influence of other indicators of the location of the accounting 20 leaves.

8. Influence of the sum of relative humidity on the growth of birch leaves on the perimeter

From figure 9 it can be seen that, as in other graphs, the size parameters of leaves in the growing season have two peaks at the amounts of relative humidity of about 135-140 and 570, as well as one minimum at 290-300. The second minimum does not appear, as the growing season has already ended.

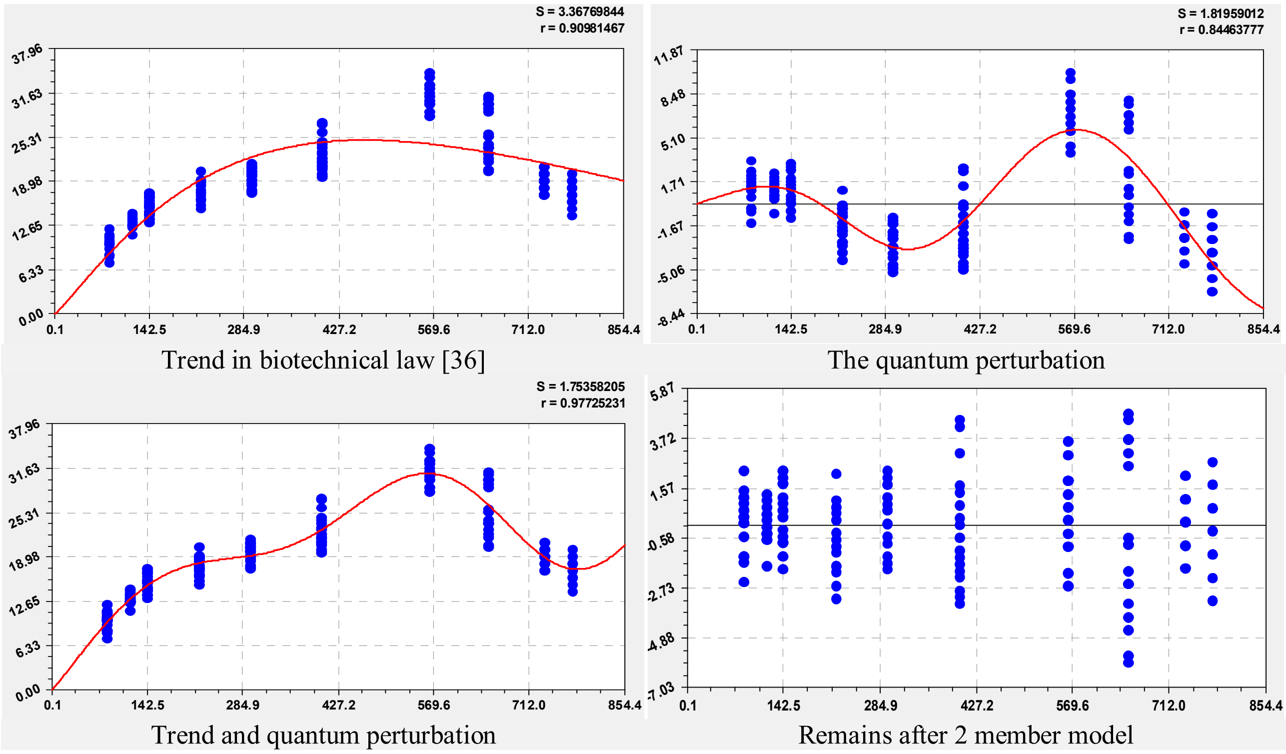


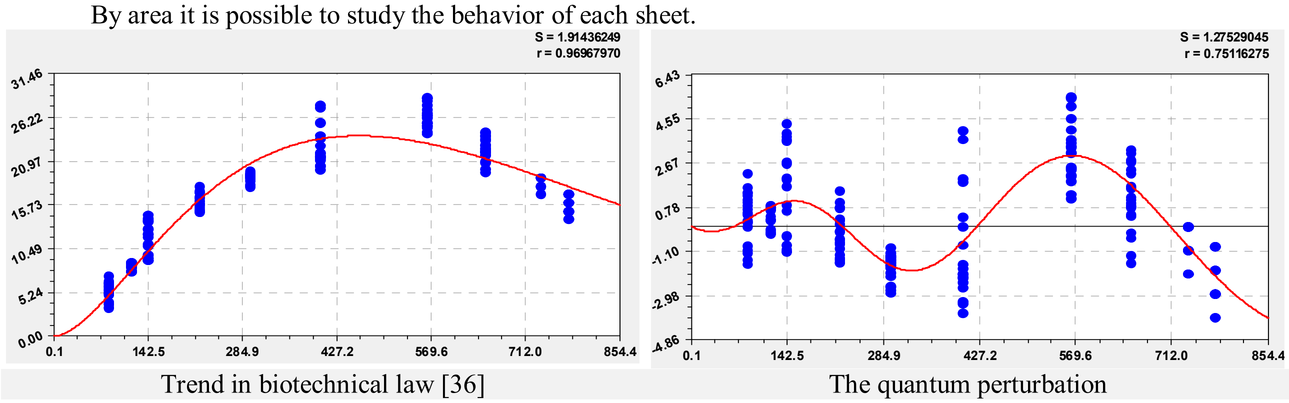
Figure 9. Influence of the amount of relative humidity during the growing season on the perimeter of birch leaves

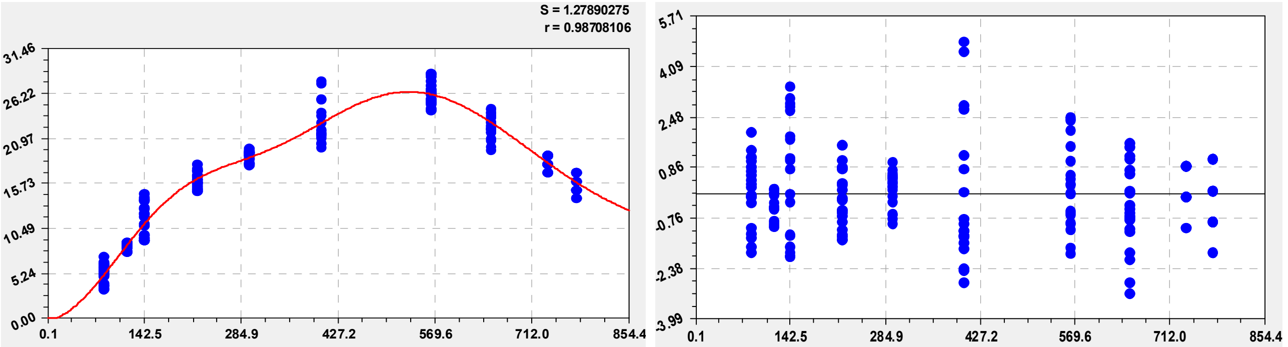
The general graph of length shows the decline, width-the desire for constancy, the perimeter by the end of the growing season even tends to grow, and the graph of leaf area also shows the decline.

9. The effect of the sum of relative humidity on the growth of birch leaves by area

The spread of residues in the parameters of the accounting 20 leaves behaves differently. For example, in figure 10 in the first half-wave to a minimum of 290 the amount of relative humidity dispersion first increases and then decreases. Then, at the stage of increasing the amount of relative humidity to the second maximum, there is an increase in dispersion due to the fact that each sheet tries to get the most opportunities and adapts to all factors surrounding this sheet of air and sunlight. In the experiments, we tried to choose groups of five leaves on one side of the world, which do not cover the sun's rays from each other.

By area it is possible to study the behavior of each sheet.





Trend and quantum perturbation   Remains after 2 member model

Figure 10. Influence of the amount of relative humidity during the growing season on the area of birch leaves

Thus, the study of each parameter of the leaves gets its methodological capabilities. For example, for the length of the leaf in comparison with the length of the petiole, it is possible to study the dynamics of individual growth and development. A measurement of the width of the sheet is more convenient and therefore it is proposed to use when comparing the places of growth of birches, taking into account the prevailing winds and pollution sources in different environmental conditions of the city, that is, for environmental monitoring of the urban environment by phyto-indexing.

10. CONCLUSION

The international society for bioclimatology and Biometeorology, founded in 1956, at the first Congress in Vienna, the main aspect of climate, which is still poorly understood, is determined by the ionization of the atmosphere [29]. Sunlight is the main resource for plants. Therefore, to improve the understanding of ionization can be approached through fitometeorologiya, that is, the study of the behavior of annual leaves on the example of birch.

Our inventions [16-19] refer to the engineering biology and bioindication of the surrounding part of the crown of trees of the air environment by measurements of dynamics in time of active life of plants from the beginning of Bud blooming to the last day of ontogenesis. The behavior of each sheet occurs as an oscillatory adaptation to changes in the ambient air. And adaptation happens for many decreasing quanta of interaction. The quantum state in pure ecological conditions of growth was obtained from the dates of measurements of parameters of 20 leaves during the growing season of birch.

The current vegetation time for relative humidity is taken into account every three hours. Air temperature and relative humidity in the surface layer are taken according to the meteorological station. Then their aggregates are calculated. From a series of three-hour measurements of relative humidity, we distinguish the quantum state in the form of the sum of wavelets, determined by the vegetation period of birch leaves (seasonal quantum of time).

The synergetic effect of the mutual influence of temperature and relative humidity is that the vegetation processes in plants are influenced by two forces: first, exponential growth with increasing meteorological parameter; second, the decrease in the values of the indicator according to the exponential growth law.

The sixth component and a half of the constant amplitude 0.50014 days received the greatest adequacy of 0.7192 (from the total correlation coefficient 0.8170). The same wavelet for the dynamics of the temperature of the received correlation coefficient 0.6880. The daily cycle of relative humidity is more important for birch leaves hanging over temperature.

The amplitude of the first oscillation varies within the relative humidity of 10%. By the nature of the hypothesis put forward the influence of the moon on the development and growth of birch leaves hanging. The half-period of oscillation at the beginning of the growing season is three weeks. There are other fluctuations: for example, wavelet number 10 has a weekly cycle. The amplitude of oscillation No. 1 increases and the period increases. Because of this, in the month of October there is a complete fall of birch leaves hanging.

Residues 50-th term is less than 0.5%. Then it can be argued that for each year at any weather station can be carried out during the growing season fractal wavelet analysis of the sum of the relative humidity of the surface layer of atmospheric air.

The rejection of daily average relative humidity and the transition to measuring in three hours the sum of the relative humidity of the air gives an oscillation with a constant half life of 0.5 day. This wavelet has a correlation coefficient of 0.4595 (17th place in the adequacy rating). The first place is taken by the second member of the General model – the law of exponential growth of cumulates (0.9997). On 2-5 places are wavelets: 0.8671 oscillation No. 3; 0.8136 – No. 5; 0.7394 – No. 4 and 0.5283 - No. 6. The first term of the model (1) in the form of the exponential death law with the correlation coefficient 0.5237 is only on the sixth place.

Comparison with the effect of temperature shows that the length and width of the sheet adequacy of the effect is almost the same (for the temperature, respectively 0.9939 and 0.9938). But relative humidity is characterized by a decreasing amplitude (increasing for temperature), while the oscillation occurs crisis with a negative sign. The length and width of birch leaves hanging with increasing temperature increase the amplitude, and with increasing relative humidity, on the contrary, reduce it.

The spread of residues in the parameters of the accounting 20 leaves behaves differently. In the first half-wave to a minimum of 290 the amount of relative humidity dispersion first increases and then decreases. At the stage of increasing the amount of relative humidity to the second maximum, there is an increase in dispersion due to the fact that each sheet tries independently and adapts to all factors surrounding this sheet of air and sunlight.

REFERENCES

1. Gudzenko D. V., Zadorozhnaya T. N., Zakusilov V. P. study of asynchronous connections between the thermal regime of the near-Equatorial zone of the Globe and the Northern hemisphere // geographical Bulletin =geographic bulletin. 2018. No. 1 (44). Pp. 90–95. doi 10.17072 / 2079-7877-2018-1-90-95.

2. Isakov S. V., Shklyaev V. A. evaluation of the intensity of the solar radiation on a natural surface with the use of geographic information systems // Geographical Bulletin. 2012. No. 1 (20). P. 72-80.

3. Kostareva T. V. taking into account the influence of meteorological factors in the development of schemes of air pollution forecast in the cities of Perm Krai // geographical Bulletin = geographic bulletin. 2017. №2 (41). P. 91-99. doi 10.17072 / 2079-7877-2017-2-91-99.

4. Kudryashova A. I. Regularities in the growth dynamics of tree leaves // Mater. II international scientific and practical conference «Socio-economic development of the territory». Penza: PGAS, 2015. P. 124-133.

5. Kudryashova A. I. Descriptive statistics of parameters of leaf shape // Problems of recreational plantings, introduction and conservation of biodiversity of the plant world: Mater. Russian scientific and practical conference with international participation dedicated to the 25th anniversary of the Cheboksary branch of The main Botanical garden. N. In. Tsitsin Russian Academy of Sciences. Cheboksary, 2014. P. 27-30.

6. Kudryashova A. I. Method of analysis of birch leaves ontogenesis at the road // V international scientific-practical conference «Actual problems of science and economy: new challenges and solutions». SPb.: Public scientific organization «Science and economy». No. 5. 2014. P. 100-103.

7. Kudryashova A. I. Method of measuring the dynamics of growth of tree leaves // Mater. II international scientific and practical conference «Socio-economic development of the territory». Penza: PGAS, 2015. P. 115-123.

8. Kudryashova A. I. Method of measuring the perimeter and the area of the tree leaf // III international scientific and practical conference «Actual issues of science and economy: new challenges and solutions». SPb.: Ls. scientific. org. «Science and agriculture». No. 3. 2014. P. 17-20.

9. Lobanov V. A., Toshchakova G. G. Methods of estimation of future regional temperature conditions (on the example of Kostroma region) // geographical vetsnik. 2016. No. 1 (36). P. 58-69.

10. Lobanov V. A., Toshchakova G. G. Features and causes of modern climate change in Russia // Geographical Vestnik = Geographical bulletin. 2016. No. 3 (38). P. 79-89. doi 10.17072/2079-7877-2016-3-79-89

11. Mazurkin P. M., Kudryashova A. I. Wave dynamics of leaf ontogenesis polluted near the highway Linden // http://research-journal.org/: international research journal. 2015.

12. Mazurkin, P. M., Kudryashova A. I. Dynamics of the ontogeny of the leaves of the tree. Yoshkar-Ola: PGTU, 2015. 172 p.

13. Mazurkin, P. M., Kudryashova A. I. Regularities of ontogenesis of leaves of trees. Dynamics of growth of the leaves of lime and birch in pure and polluted by automobile exhaust in the urban environment. Germany: LAP LAMBERT Academic Publishing, 2015. 100 PP.

14. Malkova I. L., Sarancha M. A., Belova A. A. assessment of bioclimatic potential of the Udmurt Republic // Bulletin of the Udmurt University. 2014. Issue. 2. P. 142-150.

15. Mustafina A. B. Changes in the basic climatic indicators in the territory of the Republic of Tatarstan for the period 1966-2013.// Geographical Vestnik = Geographical bulletin. 2017. No. 2 (41). P. 99-108. doi 10.17072 / 2079-7877-2017-2-99-108.

16. Pat. 2597643 Russian Federation, IPC G 01 D 21 / 00 (2006.01). Method of analysis of the dynamics of growth in ontogenesis polluted birch leaves around the road / Mazurkin P. M., Kudryashova A. I.; applicant and patentable. Mazurkin P. M. No. 2015112152/28; Appl. 03.04.2015; publ. 20.09.2016. Bul. No. 26.

17. Pat. 2597645 Russian Federation, IPC G 01 D 21 / 00 (2006.01). The way to measure the growth dynamics of tree leaves in a clean ecological conditions Mazurkin P. M., Kudryashova A. I.; applicant and patentable. Mazurkin P. M. No. 2015105273/28; Appl. 17.02.2015; publ. 20.09.2016. Bul. No. 26.

18. Pat. 2606189 Russian Federation, IPC G 01 D 21 / 00 (2006.01). Method factor analysis of the ontogeny of the account tree leaves / Mazurkin P. M., Kudryashova A. I.; applicant and patentable. Mazurkin P. M. No. 2015112149; Appl. 03.04.2015; publ. 10.01.2017. Bul. No. 1.

19. Pat. 2615363 Russian Federation, IPC G 01 B 05 / 26, G 01 N 35 / 00 (2006.01). Method of analysis of the ontogenesis of clean tree leaves / Mazurkin P. M., Kudryashova A. I.; applicant and patentable. Mazurkin P. M. No. 2015105705; Appl. 19.02.2015; publ. 04.04.2017. Bul. No. 10.

20. Pridacha V. B., Pozdnyakova S. V. Metric parameters of leaves and biochemical features of Betula pendila Var. Pendula and B. Pendula Var. Carelia and their seasonal dynamics. Botanical journal. 2010. Vol. 95. No. 11. P. 1595-1605.

21. Stockate Y. V., Vasilevskaya, L. V. long-term izmeneniia temperature of the air and soil in the extreme North-East of Russia // Geographical Bulletin. 2016. № 2 (37). P. 84-96. Doi: 10.17072/2079-7877-2016-2-84-96.

22. Tikhova G. P., Pridacha V. B., Sazonova T. A. Influence of temperature and relative humidity on the dynamics of water potential of trees Betulapendula(Betulaceae, represented by) // Siberian journal of forest. 2017. No. 1. P. 56-64.

23. Ushakov M. V. Modern changes in the thermal regime of the vegetation and winter periods in Chukotka / / geographical Bulletin = geographic bulletin. 2017. №2 (41). P. 81-91. doi 10.17072 / 2079-7877-2017-2-81-91.

24. Khuzina G. R. influence of urban environment on morphometric indices of birch leaf hanging (betula pendula roth) // Bulletin of Udmurt University. Biology. Earth science. 2010. Issue. 3. P. 53-57.

25. Shklyaev V. A., Ermakova L. N., Shklyaeva L. S.. Study of the microclimate of the city in order to assess the biometeorological indicators of the residential area / / geographical Bulletin. 2010. No. 3 (14).

26. Shklyaev V. A., Ermakova L. N., Shklyaeva L. S. Features of long - term changes in the characteristics of vegetation periods in the Perm region // geographical Bulletin. 2012. №2 (21). Pp. 68-73.

27. Shklyaev V. A., Polin D. N. Zoning of territory of Perm region on indicators of the heating period // Geographical Vestnik = Geographical bulletin. 2017. №4 (43). P. 123-135. doi 10.17072 / 2079-7877-2017-4-123-135.

28. Beggs P.J. et al. Aerobiology in the International Journal of Biometeorology, 1957–2017. Int J Biometeorol (2017) 61 (Suppl 1):S51–S58. DOI 10.1007/s00484-017-1374-5.

29. Bioclimatology and biometeorology. Nature. Vol. 180. Dezember, 1957. P. 1328-1329.

30. Chen Y. et al. The leaf phenophase of deciduous species altered by land pavements. International Journal of Biometeorology (2018) 62:949–959. https://doi.org/10.1007/s00484-018-1497-3.

31. Chen X. et al. Temporal coherence of phenological and climatic rhythmicity in Beijing. Int J Biometeorol (2017) 61:1733–1748. DOI 10.1007/s00484-017-1355-8.

32. Donnelly A., Yu R. The rise of phenology with climate change: an evaluation of IJB Publications. Int J Biometeorol (2017) 61 (Suppl 1):S29–S50. DOI 10.1007/s00484-017-1371-8.

33. He M., et al. Projections for the changes in growing season length of tree-ring formation on the Tibetan Plateau based on CMIP5 model simulations. International Journal of Biometeorology (2018) 62:631–641. https://doi.org/10.1007/s00484-017-1472-4.

34. Klimienė A., Vainorienė R., Klimas R. Phenological research of climate changes in the north part of Lithuania by the phenological garden of Šiauliai University. Int J Biometeorol (2017) 61:293–301. DOI 10.1007/s00484-016-1211-2.

35. Mayer H. Urban bioclimatology. Article in Experientia. December, 1993. DOI: 10.1007/BF02125642. PubMed: Urban_bioclimatology_Experientia_49_1993_957-963.pdf.

36. Mazurkin P.M. Invariants of the Hilbert Transform for 23-Hilbert Problem,Advances in Sciences and Humanities. Vol. 1, No. 1, 2015, pp. 1-12. doi:10.11648/j.ash.20150101.11.

37. Mazurkin P.M. Influence of Parameters of Water Regime and Hydrological Changes on the Pasture. Biostat Biometrics Open Acc J. 2018; 6(4): 555695. DOI: 10.19080/BBOJ.2018.06.555695.

38. Mazurkin P.M. Method of identification. International Multidisciplinary Scientific GeoConference, Geology and Mining Ecology Management, SGEM, 2014, 1(6), pp. 427-434. https://www.scopus.com/inward/record.uri?eid=2-s2.0-84946541076&partnerID=40&md5=72a3fcce31b20f2e63e4f23e9a8a40e3

39. Mazurkin P.M. Wavelet Analysis Statistical Data. Advances in Sciences and Humanities. Vol. 1, No. 2, 2015, pp. 30-44. doi: 10.11648/j.ash.20150102.11.

40. Mazurkin P.M. Analisi dendrocronologica series. Italian Science Review. 2014; 5(14). PP. 163-169. Available at URL: http://www.ias-journal.org/archive/2014/may/Mazurkin.pdf. 24.

41. Mazurkin P.M., Tishin D.V. Wave dynamics of tree-ring width jf Oak // Integrated Journal of British. Volume 2. 2015. Issue 1. JAN-FEB. P. 55-67. IJBRITISH-223-PA.pdf.

42. Mu Z. et al. Synergistic effects of temperature and humidity on the symptoms of COPD patients. Int J Biometeorol (2017) 61:1919–1925. DOI 10.1007/s00484-017-1379-0.

43. Niglas A, Kupper P, Tullus A, Sellin A. 2014. Responses of sap flow, leaf gas exchange and growth of hybrid aspen to elevated atmospheric humidity under field conditions. AoB PLANTS 6: plu021; doi:10.1093/aobpla/plu021.

44. O'Leary D.S., Kellermann J.L., Wayne C. Snowmelt timing, phenology, and growing season length in conifer forests of Crater Lake National Park, USA. Int J Biometeorol (2018) 62:273–285. DOI 10.1007/s00484-017-1449-3.

45. Rossi S. et al. The timing of bud break in warming conditions: variation among seven sympatric conifer species from Eastern Canada. Int J Biometeorol (2017) 61:1983–1991. DOI 10.1007/s00484-017-1391-4.

46. Sellin A. et al. Rapid and long-term effects of water deficit on gas exchange and hydraulic conductance of silver birch trees grown under varying atmospheric humidity. BMC Plant Biology. 2014, 14:72. http://www.biomedcentral.com/1471-2229/14/72.

47. Sellin A. et al. Elevated air humidity affects hydraulic traits and tree size but not biomass allocation in young silver birches (Betulapendula). Frontiers in Plant Science. October 2015 | Volume 6 | Article 860. doi: 10.3389/fpls.2015.00860.

48. Templ B. et al. Change of plant phenophases explained by survival modeling. Int J Biometeorol (2017) 61:881–889. DOI 10.1007/s00484-016-1267-z.

49. Templ B. et al. Phenological patterns of flowering across biogeographical regions of Europe. Int J Biometeorol (2017) 61:1347–1358. DOI 10.1007/s00484-017-1312-6.

50. Xiao-Fei Wang et.al. Defense pattern of Chinese cork oak across latitudinal gradients: influences of ontogeny, herbivory, climate and soil nutrients. Scientific Reports | 6:27269 | DOI: 10.1038/srep27269.

51. Zipf L., Primack R.B. Humidity does not appear to trigger leaf out in woody plants. Int J Biometeorol (2017) 61:2213–2216. DOI 10.1007/s00484-017-1428-8.